

Scaffolding the Language of Maths

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'I'm good at Maths but I'm not good at reading the Maths.'

This statement from Lewis,¹ a Year 7 Aboriginal student at Cowandilla Primary School in Adelaide, South Australia when looking at a page of word problems, was the catalyst for a teacher research project focusing on the language of written word problems commonly found in mathematical text books in upper primary and secondary schools.² Many of the students in the class were competent in working through the mathematical processes that were being taught, but when faced with written word problems which had the process embedded in a so-called 'real-life' context, had no way of interpreting the problem, identifying the mathematical processes and consequently completing the task. This issue, of not being able to access the language of maths, may be one important reason that Aboriginal students are not continuing past compulsory maths to complete their high school certificate.

Cowandilla CPC-7 School is a complex school serving a near-city community with a very mixed population. The students come from about 15 different ethnic backgrounds, and approximately 20% have come to Australia as refugees. Many parents are unemployed and live in rental accommodation, with 68% receiving School Card to assist in paying school fees. Many families are single parent families, and there is a high degree of transience amongst the student population. There are currently 40 Aboriginal children attending the school, and several of the families regularly move between country and city locations. Of the 2002 graduating Year 7 students, only two had been at Cowandilla for their entire primary education.

As Middle Years Project Officer for Aboriginal Education, and Principal of the school, we were aware that students were likely to encounter mathematical pedagogy relying on 'working from the maths text book' once they transferred to high school. With school-based colleagues, we sought to identify firstly the language demands of such a program, and secondly how we could prepare students to successfully manage the given tasks. (The appropriateness of such textbook pedagogy is a significant question, but is not the focus of this research.)

This paper is divided into three parts: firstly, what are the linguistic demands of the maths curriculum? We look at the language demands of maths in general, then more specifically maths textbooks, and finally, the language of word problems. It is important that we can articulate what may need to be explicitly taught if students are to access the language in maths. We have both worked extensively with students using the functional grammar of Halliday (1974). Analysis using this grammar has proved to be a valuable and liberating tool in developing a meta-language for discussion with students. In our case, our focus has been on supporting the learning of Indigenous and English as a Second Language (ESL) students.

Secondly, once we had established what we thought students needed to know, how did we go about making that language accessible to the learners in this Year 6/7 classroom, in particular the large number of Indigenous students and ESL students? Both the project officer and some staff in the school were familiar with or had taught using Brian Gray's

‘Scaffolded Literacy’ pedagogy, developed through working with Indigenous students around Australia (Rose et al. 2000). We wanted to establish how this pedagogy might be adapted to support students in the language of mathematics.

Thirdly, what were the outcomes for Indigenous students? Pre- and post-interviews were conducted with three Aboriginal students in the class, then we analysed this data to see if this process did, in fact, assist students in accessing and having control of word problems.

What are the linguistic demands of the mathematics curriculum?

General linguistic challenges

Many Australian writers contributed to our knowledge about the complexity of mathematical language in general (Jackson 2002, Mousley & Marks 1991, Veal 1997, 1999). As part of our preparation, we examined the textbooks commonly used at Cowandilla and a nearby high school to identify language aspects that might create difficulties in making meaning for our Aboriginal and ESL learners. What follows is a brief summary of the more general grammatical and linguistic challenges of mathematical language, as exemplified by an activity from a Year 7 textbook:

Submerge the measuring cylinder in the water of the partly filled aquarium, then invert it as shown in the diagram, making sure that no water escapes.
(Pulgies et al. 1998, our emphases)

1. High density of mathematical sentences: unlike talk, mathematical sentences contain a large number of ‘content’ words, and fewer ‘grammatical’ words. For example, in the above sentence, the content words are highlighted in bold. They constitute more than half the sentence. The sentence is made even more complex by the inclusion of technical terms such as *submerge* and *invert*, or as we explain to the students, ‘flash’ words. To complete the task successfully, students need to carefully read most words, because they matter. In addition, they need to understand the meaning of the technical language.
2. Grammatically complex sentences: the same activity demonstrates the challenge of making meaning from such complex sentences. The instruction above is one sentence made up of two independent clauses. In themselves, two clauses joined by ‘then’ are not so difficult. However, when the grammar of each clause is analysed, the complexity becomes evident. There are many ‘bits’ to each clause:

Verb	the thing (what)		where	
<i>Submerge</i>	<i>the measuring cylinder</i>		<i>in the water of the partly filled aquarium,</i>	
When	verb	the thing	how	how
<i>then</i>	<i>invert</i>	<i>it</i>	<i>as shown in the diagram,</i>	<i>making sure that no water escapes</i>

In order to complete this activity successfully, students need to be able to group words into these meaningful ‘bits’ as they read, store the meaning and enact it in sequence. (The text contains a diagram to show students how to *invert*, as long as they understand the purpose of a diagram.)

3. Complex and lengthy noun groups: *the water of the partly filled aquarium* is one example of the lengthy groups of words which form around nouns to make meaning together in mathematical sentences. Lengthy noun phrases are also an important part of mathematical definitions sprinkled through textbooks. In the following example, the noun group is in bold: *A line design is a geometric pattern formed by straight lines joining various points on one or more angles* (Andrew 1995, p. 110). Students who are often not confident readers have great trouble picking up, as they read, all the important meaning contained in such a phrase.

Challenges of maths text books

Part of the issue for middle years students is the transition from primary level maths textbooks to secondary. Unlike many primary level classrooms, the textbook is central to the maths program in many secondary classrooms. The textbook functions to fulfil many purposes: to gauge what students can already do, to explain the history of particular topics, to teach new mathematical concepts, to revise, to consolidate and practise. Each author develops their own structures in order to complete these functions.

Unfortunately for the fragile reader, there is a great diversity in structural use of boxes, shaded boxes, headings and sub-headings to denote different and useful purposes for the text. Not only is there no consistency from textbook to textbook, even within one textbook, one feature can have different purposes. For example, in the textbook we examined used by a nearby high school (Andrew 1995), a green shaded box can function to enclose any of the following: a mathematical definition: *Complementary angles add up to 90 degrees* (p. 112), a reminder: *If you see the word 'of' in a fraction problem, replace it with x and do the multiplication in the usual way* (p. 76), or a mathematical process: *Follow these steps to convert recurring decimals to fractions ...* (p. 173). Our guess is that the writers include these different purposes into the more general function of 'some useful extras' or perhaps 'useful reminders'. Despite the potential confusion of their multiple purposes, they are often useful resources for meeting mathematical goals. Students at secondary level not only have to navigate their way through the topics in a text book, they also need to navigate their way through the wide variety of functions performed by each section within a chapter.

The grammar at sentence level within textbooks presents a further challenge for fragile readers and mathematicians. Passive voice, often unfamiliar in oral texts, is a common grammatical strategy in technical texts. It is often used in describing maths processes because the doer, or the agent, is irrelevant to the maths processes being explained, e.g. *The volume of a lunch box could be measured in cubic centimetres* (Andrew, p. 218). Just who measures the lunch box does not matter. Passive voice is not difficult once it has been explained, nor when students can anticipate its use, but can create confusion if students are expecting the 'who' or the 'doer' at the beginning of sentences as it is commonly found in narrative texts.

Students who are able to understand maths textbooks have access to many resources that may help them in their tasks. However, our opinion is that such access would require, in many cases, that the teacher works through the maths text book, making the functions of different parts explicit and therefore accessible to fragile readers.

In contrast to this complex genre, students at primary level are often faced with simpler challenges. In the class with whom we worked, the teacher, after teaching new concepts, handed out worksheets such as the one shown in Figure 1 for consolidation.

While the sentences are still linguistically dense and terms still often technical, the grammar at sentence level is simpler and easier to read. There is no textbook through which to navigate; rather there is a generously spaced page, with large font and plenty of space for recording answers. Students may be able to work on such worksheets more independently, but our question became: How do students make the leap between the more simple linguistic challenges of the worksheet and the complexity of the maths textbook?

The challenge of word problems

'Word problems', for the purposes of our research, are maths problems that contain elements of real-life contexts. As well as attempting to consolidate conceptual learning, they show how the mathematical concepts might be applied in real life, e.g.

If each page of a book is 25cm by 15cm, find the total area (in m^2) of paper used in a book 420 pages. (Pulgies et al. 1998, p. 375)

The first issue for students whose cultural experiences are not those of middle class white Australians is the need to suspend disbelief: for some Aboriginal students of Cowandilla, the idea that we should bother to measure such a process might seem a nonsense. They may ask, 'Who cares?'

Zevenbergen (2000, p. 12) helped our team by elaborating on this issue with lower socio-economic students. Informed by Bernstein's work (Bernstein 1996, p. 31), she found that word problems such as this, containing 'real-life' contexts, somehow prevented some students from recognising the problem as part of mathematical discourse. Consequently, their realisation of the problem used everyday, rather than mathematical terms and processes, and focused on their own real-life experiences, rather than the 'pretend' ones represented in the word problems.


In order for students to engage with and understand these word problems, they first need to understand their purpose; to suspend disbelief, and make-out or pretend that these could be real-life problems for persons unknown.

The second issue with word problems is their grammar. They do have a predictable structure or 'stages'. Veel (1994) has identified this as three-part: situation/specifications/task. However, our examination of the textbooks used locally led us to simplify this to two

More Containers


Module 2

1




How many one-litre containers of juice would be needed to fill ten 200-millilitre bottles?

2




What size container would you need if you were mixing together 500 millilitres of cordial with 1 500 millilitres of water?

3




What size containers would you need if you were sharing $1\frac{1}{2}$ litres of lemonade among three people?

4



If you pour 250 millilitres of milk from a 1.5-litre container, how much milk is left in the container?

5



A dog's paddling pool holds 10 litres of water. How many times would you need to empty water from a 1.5-litre container to fill the pool?

Figure 1 (Williams 2001, p. 23)

parts: *given information* and *task*. We decided that what Veal called the *situation* was too often intertwined with the specifications in the one sentence to clearly mark them as two sections. Our notion of ‘given information’ included both the context and the specifications or dimensions.³

Although the staging in word problems is clear, the language choices within each stage are varied. The *given information* stage usually functions to tell us the context: who, what, where and sometimes when and why. For example:

Where	who	action	what	where
<i>At the show,</i>	<i>a young child</i>	<i>spreads</i>	<i>a patch of bubble gum</i>	<i>on his nose</i>

Sometimes the task is more easily identified because the context and task are separated into two sentences. However, as in the following example, which coincidentally contains passive voice, both the context and the task are found in one sentence:

Task	Given information
<i>Find the capacity</i>	<i>of a jug if it can be filled by 5 glasses of water, each 200 mL.</i>

The *task* stage can also be realised by many different word choices. In the word problems we worked on, the meaning of the task was always ‘calculate the volume’, but here are some of the word choices: *what volume of cement will be need to order*; *how much manure will she need*; *find the capacity of a jug*; *how much Coke have I drunk*, etc.

It is a significant challenge for students who are not confident readers or mathematicians to be able to recognise which words within a problem represent the task, and which are part of the context around the task. It also helps to understand that the context, while providing a purpose for the task, is not particularly important for successfully completing the word problem: whether the task is being carried out by a bridesmaid, ‘Sebastian’, or a contractor does not matter. Nor does it matter if the task is being carried out at Cowandilla Primary School, the show or at a wedding.

The challenge for us as teachers was how to assist students in accessing this language, in sorting out the mathematically important from the unimportant, and in recognising what constituted the mathematical task hidden somewhere in this mass of seemingly irrelevant verbiage.

Using Scaffolded Literacy to access word problems

In our efforts to take on this challenge, we turned to the pedagogical resources provided by Scaffolded Literacy, developed by Dr Brian Gray from the University of Canberra. Scaffolded Literacy is a literacy learning process that has been used with considerable success with Aboriginal learners (Rose, Cowey & Gray 2001). While ‘scaffolding’ was a term used first in educational contexts by Bruner in 1976, Dr Gray has developed an explicit sequence of scaffolds to support the learner as needed. Teacher and learners move together from reading and interrogating written texts, through developing a sight word and spelling vocabulary, then take useful resources from that original text to use in their own carefully supported writing. Its theoretical base includes Halliday’s functional grammar (Halliday 1976), and a Vygotskian understanding of learning as a socially embedded and mediated act (Vygotsky 1962).

Before we began this part of the project, the classroom teacher had already identified her teaching topic, measurement of capacity and volume, and made sure that the students in her class understood volume and capacity, and could carry out simple capacity calculating tasks. They were ready to apply this knowledge to word problems.

Our goal was to investigate how Gray’s sequence of scaffolds, which we had previously

used with narrative texts, would work in the explicit teaching of these brief but complex word problems. What follows is a description of how the class was involved in careful text analysis of a page of word problems, leading to the writing of their own word problems to share with their friends. The word problems had been written by one of the authors to represent a range of possible grammatical and lexical realisations of word problems about capacity and volume. The terms used for each step of the scaffolding sequence are Gray's.

Lower order book orientation (LOBO)

The purpose of the LOBO is to identify and understand the social function of this text, and any generic features, such as staging, that are consistent with similar texts. The LOBO is a succinct but often overlooked part of any discussion about texts; how often do we explain the social function of narrative or science reports? Most of the genres used in schools are valued Western constructs, and it is important for all students, not just migrant and Aboriginal students, to understand them as socially constructed.

In this case, we talked explicitly about why authors of maths books write word problems, and what the functions of word problems are. We explained that they are made up, and that although they try to seem like real-life stories, they may sometimes seem quite odd. We talked about the need to pretend that they were real, even if they seemed stupid.

Higher order book orientation (HOBO)

The HOBO takes a closer look at the text, the functions of particular groups of words within the texts, and the language choices that the author has made to realise those functions. In this case, we initially chose one word problem to focus on, and looked closely at how words functioned together:

A contractor is cementing new paths at Cowandilla Primary School. What volume of cement will be need to order for a path 20 metres long, 1.5 metres wide and 100 millimetres deep?

As well as students having their own copy of the word problems, they were also displayed on the overhead projector, an important strategy for focusing student attention when they were not sure of what to do.

As part of this step, students were asked to highlight with one colour the words that provided us with *given information* and with another colour the *task*. We did this first together with the overhead projector, and gradually, as the students worked their way down the problems and became more confident, this particular scaffold was removed. We then worked at sentence level within the *given information* stage, identifying which groups of words function together in the sentence. The word problem was 'chunked' in the following way:

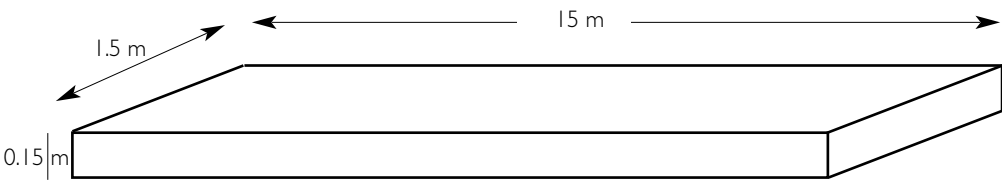
Who	verb or action	what	where
<i>A contractor</i>	<i>is cementing</i>	<i>new paths</i>	<i>at Cowandilla Primary School.</i>
calculate	3D object	dimensions	
<i>How much cement would be need to order</i>	<i>for a path</i>	<i>15 m long, 1.5 m wide and 15mm deep.</i>	

Transformations

Transformations move the words from their original place in a text into a mode where they can be easily manipulated. They are written on strips of card, and displayed on a sentence maker (probably last used in the 1980s!). This step transforms an author's words into grammatical resources that students can use in their own writing. There are several parts to

transformations: once again we ‘chunked’ the sentences into meaningful bits. This time the students were more confident and were beginning to tell me how the words functioned.

We introduced a new aspect of transformations that was not previously present. Our ‘think tank’ of teachers at the beginning of the project was convinced that recording the problem visually would help many students in creating meaning from the task. Thus, we developed and trialled a pro-forma, which we hoped would organise the word problem into its different stages. This particular maths problem was represented something like this:

Given information	Task	Mathematical calculation
Contractor, cementing path, CPS (Cowandilla Primary School) Dimensions: 15m x 1.5m x 150mm deep	How much cement	1. Convert mm to m $150/1000 = 0.15\text{m}$ 2. $15\text{m} \times 1.5\text{m} \times 0.15\text{m} = ?$ metres cubed
<p>Illustrate</p> 		

We then had a conversation around other word problems on the page, seeing how our proforma would work to represent them. (At some stage we did complete the maths process and find the answer, but that was not the focus of the discussion.)

The next part of transformations leads us forward to student writing. We began to brainstorm other contexts about which we could write. Because this was new to the students, the teacher began the thinking and talking, by suggesting the problem of working out how much sand to fill a sand pit. Then a student put forward the idea that we could work out the quantities of cement for a skate park. All ideas were listed for later reference. The purpose of this step was to get students thinking as maths writers do, about suitable contexts in which to place the volume task. Evidence that they understood this is explained later, when students’ own word problems are described.

We then focused on the smaller ‘chunks’ or functions within the sentence. Who could be a participant in a new word problem (the ‘who’)? These were listed. What task might they need to do that required them to calculate volume or capacity (the ‘what’)? These were listed. At this point the lists were left on display around the room.

Text patterning

Text patterning takes away the original author’s word choices to leave the students with a grammatical pattern. It is done by working with the students to create clues which will help them to write new chunks of words with the same function. Here are the teacher’s actual words:

*If we wanted to begin our sentence with the ‘who’, like this author has, what clue could we write on the back of our card that would remind us to begin the sentence with ‘who’? We could write ‘who’, or ‘person’, or ‘participant’ or ‘character...’
What would make sense for you?*

As the students chose their clues, they were recorded on the backs of the strips of card, and displayed on the sentence maker. In the end, the strips looked like this:

Who	action	what	where	Calculate	object	dimensions
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Short writes

Short writes involve the process of students using this text pattern or template to create their own writing. In this case, using the ideas listed previously around the room, we constructed a joint word problem. Students then worked with a teacher, in pairs or on their own, to construct their own word problem involving a volume calculation. Some examples, reflecting the strong interests of this multi-cultural group were:

Yehonnes is ordering dirt at a soccer stadium. He will need dirt a metre deep, 50 metres long and 10 metres wide. What would the volume of dirt be if we calculate it together?

A mud wrestler is preparing for a match in the mud arena. Find the volume of the mud in the ring with dimensions of 8m x 8m, if the mud is 1 metre deep.

Lisa and Lavia have built a guinea pig hutch at Cowandilla Primary School 115cm long, 50cm deep and 115cm wide. How much straw will they need to fill the whole hutch up?

These were typed up, and the student-generated problems became a worksheet. Not only did it provide new and relevant word problems on which the students could practice, it was a valuable monitoring tool to gauge how well students understood the concepts involved.

Important aspects of the pedagogy

Pre-formulating and reconceptualising questions: In addition to our careful moving from deconstructing original word problems to constructing new ones, other pedagogical strategies were also used to make sure that students were supported in their learning as long as they needed to be. The most important of these was the notion of ‘pre-formulating and reconceptualising questions’, an important strategy borrowed from Brian Gray’s Scaffolded Literacy pedagogy. Pre-formulating questions requires that the teacher provides sufficient ‘prior knowledge’ in her preamble to a question that an understanding of the purpose of the question is shared by everyone in the class, not just those few whose logic or understanding is congruent with the teacher’s. The teacher’s response to a student answer is always positive, and can build on the student knowledge by reconceptualising it so that it contributes to the building of a meta-knowledge and language. Here is an example of teacher questioning from the lessons:

Preformulation: There are some words here that are asking us how much cement does he need. But this author didn’t say ‘how much cement does he need?’

Question: What words did this author use?

(Student: What volume of cement.)

Reconceptualisation: That’s right. And that’s the clue. ‘Volume’ gives us a clue that this is going to be a volume problem.

Previously, our default questioning, pretending to be open-ended, would have been something like: *What does this first sentence tell us?* Only those students with prior knowledge about what is important in mathematics, and with logic congruent with the teacher, would have been able to answer this question.

As shared knowledge and understanding is built and internalised, the pre-formulation is

taken away, and the questions can stand by themselves. This pattern occurs across time with any learning topic, but pre-formulation always occurs for any new learning, and at any time that there is evidence that students do not understand what the teacher is talking about.

With our knowledge of the frequency of 'interactive trouble' (Freebody, Ludwig and Gunn 1995) in disadvantaged classrooms, pre-formulation has probably been the most important pedagogical change for scaffolding teachers that has provided access to the curriculum for disadvantaged students.

'Knowing how to pre-formulate questions has changed the way I think about questioning my kids. I use pre-formulation throughout the day, not just in literacy lessons.'
Katrina Sexton, Reception/Year 1 teacher at Cowandilla.

Modelling to independence: The expectation is that any new learning will be modelled initially by an informed other, often the teacher. Students are then supported through their new learning to the stage that they can work independently, but there is no expectation of how long it will take to reach that point. Different students, with differing levels of congruence with school learning and different language abilities, will take as long as they need to master any learning. The following list shows the steps that the students went through from modelling to independence in this instance:

Deconstructing word problems:

- Teacher modelled text analysis of word problems on overhead projector so that all students had a shared focus.
- Individual students were invited to help underline on the overhead projector.
- Students underlined one word problem on their own copies using highlighter pens. All teachers in the room checked to make sure that the students understood what they were doing.
- Students then continued to deconstruct other word problems either in pairs, or independently.

Reconstructing word problems:

- Teacher negotiated with the students a list of possible contexts where volume problems would be relevant.
- Class negotiated together the text pattern from the original word problem (this task takes many repetitions before students can carry it out independently).
- Using the text pattern already established, teacher and students negotiated a new word problem together on the blackboard.
- Teacher made sure that all students had identified a new context for their word problem. (If they wanted to use the same one as we had already chosen on the board, that was fine.)
- Students worked individually or in pairs to construct a new word problem.
- Students read their word problem to the rest of the class.

What were the outcomes for Indigenous students?

The aim of this project was not for students to successfully complete Mathematical word problems, but to successfully access, understand and be able to talk about word problems. The final calculation was not the important part. Consequently, our student data collection was comprised of transcripts of the three Aboriginal students, Hayley, Ben and Lewis, explaining to the school principal how they would work through particular word problems. The same problems were presented before and after the teaching.

It should be noted here that there was a significant flaw in our assessment design. We assumed that students would, at this point, be able to not only calculate volume of solid objects, but also to convert cubic metres to litres in order to calculate the capacity of liquids. Unfortunately, students had not reached this stage when the work on word problems began, and this omission is very visible in the post-project data. The word problems we had selected for baseline data included the need to calculate the volume of liquids. Students were not familiar with, nor confident to carry out, those parts of the word problems. Nevertheless, there was plenty of evidence that the four lessons had made important improvements to student outcomes.

After analysing the student responses, several indicators were identified that showed the growth in skill and confidence of the students.

Number of teacher interventions to ask for elaboration or clarification:

When the students were first interviewed, it was apparent that the interviewer intervened when she thought necessary to encourage and help the students with their answers. She reassured students (*I reckon that would work*), reworded the task (*You don't have to do the working out, just tell me how you would solve that problem*), and asked for elaboration (*How did you work that out?*).

Hayley received 4 interventions in the pre-test, and 1 in the post-test.

Ben received 10 interventions in the pre-test, and 1 in the post-test.

Lewis received 7 interventions in the pre-test, and 2 in the post-test.

These interventions were not usually a result of student requests, but of the interviewer's monitoring of how the student was faring, and her perception that intervention was necessary. It is apparent that she thought much less intervention was necessary to come to a satisfactory conclusion in the post-test. The students were more confident to be left to complete the task on their own.

Modality showing certainty and uncertainty:

Students demonstrated their lack of confidence in a few ways.

Hayley's first transcript showed many pauses, hesitations while thinking was happening. These pauses were combined with unfinished sentences: *First I would like try to make the box and ... how many 300mL spring water bottles ... I just added ... I have to times them ... I was just like trying to see what ... did add them up, what it would be, metres.*

In contrast, no pauses are evident in the second responses for either question.

Ben asked clarification questions in the pre-test: *So how much is 300mL? How does that relate to all this stuff here?* And in Problem 2: *Am I supposed to find out how much rubbish they could fit into there or how much room they would have?*

Only one similar question was found in the post-test: *Wouldn't you must like make the hole deeper or something, like to dump the extra 2 metres on top?*

This student also talked quietly to himself and mumbled answers that the transcriber could not hear during the pre-test, whereas the post-test was clear and succinct.

Lewis in the pre-test offered very little information without being prompted. However, in the post-test came the following strong statement: *I'm certain the answer is how many you'd fill up.*

Use of mathematical language:

Students used some mathematical terms in the pre-test, but not always accurately. Hayley used a term for division when multiplication was called for: *Just write it down, like $150 \times 80 \times 17$ in a long division kind of way.* Even though she read the term *rectangular prism* as she

read the problem out loud, she then talked about *the box*. The student did not use the term *cubic metres* in the pre-test, but did in the post-test.

Ben did not use any mathematical language in the pre-test, apart from that contained in the question he read out loud. In the post-test he used the terms *depth of two metres, times, and 3 metres, then 2 metres, then ... and that's 1.5 metres*.

Lewis in the pre-test used 'split up' to mean 'divide'.

Students did use more mathematical language related to volume and capacity in the post-test, but sadly not as much as we hoped. Terms such as *height, depth, and rectangular container* appeared in the post-test.

Evidence that the student can recognise, access and articulate the mathematical task inside the word problem:

We would have to say we were alarmed by the pre-project data. The general reaction from students seemed to be a hopeful 'times it all', regardless of the context. As explained earlier, we inadvertently made the assessments more difficult by including many questions containing mathematical calculations which the students had not learned. Nevertheless, the data shows that students did have greater access to the maths inside the questions, even if they could not yet successfully complete the task. Here are Lewis's solutions to the following problem, both before and after the scaffolding.

Maths problem 2: Engineers dug a 150m x 80m x 17m deep hole to dump the town's rubbish. How much compacted rubbish can be dumped if the engineer needs a depth of 2 metres of soil on top, once the hole is full of rubbish?

This problem requires students to first subtract 2 metres from the depth of the hole in order to calculate the amount of rubbish. In his pre-test, Lewis had this solution:

First I'd times 150m, 80m 17m x 2 and see what it all adds up to and then like the first up there, like 150 x 20, that would be how much rubbish they'd need, and I'd times 2 to see how much it is full of soil that's going to go on the top.

Whatever Lewis intended, it was going to be difficult to come to an accurate answer. However, his answer in the post-test made us all glow! It came with such certainty and confidence, full of technical mathematical language and a clear understanding of how to solve the problem:

150m is its height, and 80m is the length, and the 17m is how deep it is, and then you need 2 metres of soil. Well you have to take 2 off the 17, which is 15 metres deep, so it would be 150 x 80 x 15, because they need the 2 metres of soil on top.

While he chose not to use the diagram in his post-test, it is evident that something we did had made the word problems more accessible.

What we have learned

About the language of maths textbooks: We cannot take for granted that students will be able to make sense of the myriad of ways maths books are constructed. We need to work on a meta-understanding of why textbooks are created the way they are, and work with students to identify the function of different parts of maths books.

About using Scaffolded Literacy pedagogy in order to access the language of maths: The slow and careful spirals of learning that went on as part of the maths language lessons certainly helped students to develop an understanding of the structure of maths problems, and

eventually to write their own. We were alarmed though, at how much close attention needed to be paid to our classroom talk to achieve our goals, and how the omission of a small word could prevent us from achieving one of our goals: when we analysed the word problems, we worked with students to identify the words in each problem that functioned to tell us 'calculate'. They did that very well by the end. However, none of the students used the words 'volume' or 'capacity' in their post-test, and we realised that we had not included those words in our deconstruction of the word problems. Rather than looking for the words that functioned to tell us to simply 'calculate', we should have been looking for the words that functioned to tell us 'calculate volume' or 'calculate capacity.' When teachers use so many words as part of their classroom teaching each day, it is of concern that such an oversight had such a significant impact on student talk and control of language.

About student outcomes in accessing maths problems: Deconstructing maths word problems did seem in many cases to assist the Aboriginal students in the class with understanding and accessing the maths hidden inside. Of course, in hindsight, we would have chosen less complex assessment tasks in order to collect the pre- and post-data, maths problems that more accurately reflected the content the students had covered in class.

Nevertheless, the transcripts and classroom work show that students had indeed grasped the structure, and were far more confident in 'having a go'. The transcripts suggest that scaffolding the maths word problems supported students when the concepts were already established, but did not mean that they could, at this stage, successfully carry out the problem if they did not understand the processes involved. The pre-tests showed that even when students did have some concepts established, they could not successfully complete the problems before the scaffolding. Our conclusion is that the 'building the field' and the understanding of the generic structure of maths problems are both needed for their successful completion.

What now?

We think this work is important, and the learning has been used again this year. The principal, Julie Hayes, has continued working with the Year 6/7s in Mathematics. There have been interesting developments. Cowandilla teachers have been reflecting on Veele's (1999) proposition that 'students are rarely given the opportunity to occupy the role of "knowers" or "producers" of mathematical knowledge.' To counter this, students are now working together in groups to solve problems, using their own modified version of the proforma we developed.

Most students are now very discriminating about the information they record in the 'Given Information' section, selecting only the aspects that they think are relevant to the maths calculation. Each group works through to an agreement on how to solve each problem then presents it to the class. The quality of discussion, and the arguments generated within groups and the whole class are rich and empowering. Students are spending up to an hour-and-a-half on one problem, an initial concern for the teacher, because they weren't getting through much work. However, this ongoing classroom talk supports the value of our work on making these careful changes in our pedagogical practice: students are now spinning 'a rich web of mathematical knowledge' (Veele 1999).

Notes

1. All student references in this article are pseudonyms.
2. The project was funded by the Aboriginal Education Unit, SA Dept of Education and Children's Services. An earlier and abridged version of this paper will be published in *Partnerships for Success* by the Aboriginal Education Unit.

3. Since completing this project, Dr David Rose, from the University of Sydney, has suggested that we view these 'bits' of the problem as functions, rather than stages. Whereas stages occur in sequence, functions do not need to. This has changed our understanding, but for the purposes of this report, we stay with our previous analysis.

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